SOIL CONSERVATION

HENRY A. WALLACE
Secretary of Agriculture

HUGH H. BENNETT
Chief, Soil Conservation Service

VOL. V • NO. 3 ISSUED MONTHLY BY THE SOIL CONSERVATION SERVICE, DEPARTMENT OF AGRICULTURE, WASHINGTON SEPT. • 1939

MULCHING NORTHEASTERN ORCHARDS

By GROVER F. BROWN [1]

AFTER the cyclonic winds and gully-gouging rains of last year's Atlantic hurricane, many New England orchardists learned the value of mulching under their trees. The practice was recommended by research and extension workers to help in reestablishing damaged root systems of partially uprooted trees that were pulled back and reset. It proved particularly valuable in conserving rain for use by the extremely weakened tree roots and also eliminated competition of weeds for moisture and food nutrients. The protective mulch covering especially benefited trees on heavy soil with poor aeration.

In New England, as in most of the Northeast, there are farm orchards in almost every farming section, but commercial producing units are confined to a relatively few States where no such catastrophic measure as a hurricane is necessary to impress upon the minds of growers that mulching is one of the fundamentals of soil management in productive orchards.

The use of mulch is not new. It can be traced back almost to the beginning of commercial production of certain crops. Its use in orchard soil management, however, is probably confined to the last 40 years. Three outstanding pioneers in orchard mulching were F. T. Bergon, of Delaware County, Ohio; Grant Hitchings, of Syracuse, N. Y.; and A. E. Janson, of New Platz, N. Y. Mr. Janson lays claim to the oldest McIntosh block in the Hudson River Valley; on it he has practiced mulching for the last 25 or 30 years. For the last 20 or 25 years he has applied no mineral fertilizer of any kind, yet his average yield has been from 20 to 30 bushels per tree. The Ohio Experiment Station was also among the first to seek definite information relative to the practice and economic use of mulching in orchard soil management.

Dr. Brown inspecting straw mulch under apple trees in a mixed planting of peaches and apples near Hancock, Md.

The term "mulch" has a variety of meanings. For the purpose of this discussion, it is considered as any material placed under orchard trees in sufficient quantity practically to eliminate growth of grass or weeds. There are about six modifications of the mulch system of soil management which fit this general definition.

[1] Chief, regional agronomy division, Northeastern Region, Soil Conservation Service, Upper Darby, Pa.

171505—39——1

For instance, there may be mulch to the periphery of the trees with sod in the middles; mulch under the trees with the middles clean-cultivated; mulch under the trees with the middles following a cover-crop system; mulch with inter-crops in the middles; mulch with no attention given to the middles; and, mulching of the entire orchard to prohibit weed growth.

One of the primary functions of mulch is its control of soil erosion. In view of the scarcity of desirable orchard soils and sites, this is highly important, not only from the standpoint of the life of an individual block, but for the continued production of profitable blocks on the particular site.

Aeration of the surface soil is improved under a mulch system of soil management; there is better biological activity with a consequent beneficial effect upon soil fertility. Soil structure has been markedly affected under mulch. For instance, a covering of mulch does not permit compaction of the surface soil often resulting from a hard rain; it does permit rapid penetration of moisture. It is in fact a greater factor in moisture penetration than any other, including soil type itself.

The conservation of moisture and its subsequent utilization by the tree is of fundamental importance to the grower on any good orchard site. As shown by the Ohio Experiment Station,[2] the moisture absorption under mulch was 30 percent faster than under corresponding sod, and 60 percent faster than under a cultivated system immediately adjacent to the mulch. Along this line, observation in mulched orchards shows a definite development of roots immediately under the mulch. In most instances, these are all feeder roots, which will develop under mulch wherever conditions are favorable. Gourley,[3] at the Ohio station, traced relatively large roots, near the surface of the ground, until they came to the edge of the mulch where they immediately turned downward, in search of more favorable conditions. This indicates that the placement of the mulch should be well beyond the drip of the branches to widen as much as possible the feeding zone of the roots, so that the tree may be supplied with optimum amounts of moisture and food nutrients. In view of the fact that under mulch the fibrous roots increase in number near the surface of the ground, it is logical to believe that such roots will be in a position to make the maximum use of light thunder showers, which are insufficient to wet the soil to a depth that would be beneficial to roots farther down in the soil. This may be of particular importance in dry years, when rainfall is in the form of light summer showers.

Practically every investigator reports modifications of soil temperature under a mulch system. Where winters are severe, a mulch layer may be of extreme importance in preventing frost penetration to a depth sufficient to cause permanent injury to the tree. In summer, there appears to be a definite leveling off of extremes in temperature variations, and this, naturally, is conducive to bacterial activity and nitrate development. As a matter of fact, it has been found that nitrate development becomes more uniform throughout the entire growing season under mulch than under cultivation.

Various kinds of mulching materials have been used on practically every type of fruit grown in the Northeast. Perhaps the straw of small grains leads the list. However, pea vines, bean vines, spoiled hay of various kinds, saltgrass hay, cornstalks, manure and, in fact, any type of material that can be cut and hauled to the trees, has been used.

Many growers have found that mulch is very advantageous for apple varieties, such as McIntosh, Williams, Wealthy, etc., that have a tendency to drop. By placing a heavy mulch under the tree, these drops may be gathered with practically no loss in total production. In fact, some of the growers even take mulch from beneath early maturing trees, after they have been picked, and place it under later maturing varieties, to catch their drops.

A number of reports have been made relative to the increased mineral nutrients under a sod system of orchard soil management, Wander and Gourley[4] found that the potash content under mulch amounted to approximately 1,000 pounds per acre, while trees under cultivation only 40 feet away showed approximately 175 pounds per acre at the same depth. Furthermore, there was approximately twice the amount of organic matter in soil under mulch as under clean cultivation.

In Massachusetts,[5] observation showed very definite increases in growth and bud formation of trees with the mulch system of orchard soil management. This increased growth and bud formation produced increases in leaf production, and, of course, increases in fruit production. This is a matter of primary importance to the commercial grower, as his margin of profit is often determined by a slight increase in yield per tree.

[2] F. H. Beach: Apple Production Under the Mulch System. Annual Report of the State Horticultural Society of Michigan, 1937.

[3] Reported in the paper cited in footnote 2.

[4] I. W. Wander and J. H. Gourley: The Potassium Content of Soil Beneath a Straw Mulch. Science, December 10, 1937.

[5] J. K. Shaw and L. Southwick: Heavy Mulching in Bearing Apple Orchards. Bulletin 328, Massachusetts Agricultural Experiment Station. March 1936.

Mulch has been found to stabilize yields, especially in years when weather conditions are quite unfavorable. This is of particular importance, because widespread unfavorable weather conditions are reflected in a higher price to those few producers who have good crops to sell. There is some evidence to indicate that increased terminal growth and leaf may be effective in establishing the production in "off" years of some varieties of apples. A small increase in size of each fruit means a very considerable increased total yield and a decrease in the number of small or culled fruit.

On an individual farm mulch may be produced on land that is not suitable for orchards. The purchase price of straw or spoiled hay, delivered to the orchard, varies; often it is one of the primary factors prohibiting wider application of the mulching practice, since the initial application is expensive. This often necessitates the mulching of part of the orchard each year, until the entire orchard is finally covered. It usually requires from one to three tons per acre, annually, to maintain a mulch of sufficient depth and density to prevent weed and grass growth. Many growers, however, could produce a great deal more mulching material in the tree middles, especially in young orchards, if they would give proper attention to line and fertilizer practices similar to those used by general farmers in the production of high yields of hay.

Increased possibility of mouse damage, fire hazard, increase in certain insects which may be benefited by the ground cover and the possibility of too great a supply of nitrate late in the season, which might result in immature wood and possible winter injury, are some of the common objections to the use of mulch. Mice may be adequately controlled by following a definite poisoning campaign and protecting the tree trunks by eliminating any mulching materials within a radius of 3 or 4 feet from the trunk. Fire hazard is greatest when mulch is first applied, and becomes increasingly less as the material gradually decomposes. Fire lanes left every few rows minimize fire hazard, even when the mulch has just been applied. As far as insect control is concerned, with the increased knowledge of insect control and better equipment now available, the use of mulch should not present insurmountable obstacles. The fourth major objection, namely, that a surplus of nitrate may produce fruit of rather poor color, may be justified, although the evidence on this point does not seem to be very conclusive. Viewing the objections, it seems that careful attention to all these details in the management of an orchard are essential under any practice of soil management if it is to be successful.

The amount of mulch which has been used by the various growers throughout the Northeast varies from 3 to 13 tons per acre, depending upon the depth and the extent used. To be most effective, a mulch should be approximately 6 inches deep over the area covered, which in most cases means the ground under the spread of the branches, with the exception of the area immediately surrounding the trunk which is left bare for protection against mice. The following table by Prof. M. A. Blake,[6] of the New Jersey College of Agriculture, gives amounts generally recommended for apple trees in that State. In general, they are approximately the same as other growers throughout the Northeast are using, with the amount varying in proportion to that available at any particular time.

Mulch material required for apple trees per acre

Distance	Number of trees	Tree spread	Area covered	Mulch required *	
				A	B
		Feet	*Square feet*	*Pounds*	*Pounds*
40 by 40	27	25	13, 230	4, 410	7, 560
40 by 40	27	30	19, 089	6, 363	10, 908
40 by 40 **	52	25	25, 480	8, 493	14, 560
40 by 40 **	52	30	36, 764	12, 255	21, 008
20 by 20	108	15	12, 116	6, 372	10, 923

* A. One pound per 3 square feet; B. 1 pound per 1.75 square feet.
** With trees interplanted in centers of squares.

On the whole, it appears that the use of mulch is definitely on the increase in the Northeast and that the benefits are becoming appreciated by a greater number of growers each year. The investment which is necessary for fruit growing in the way of spraying equipment, warehousing, supplies, etc., together with the need for maintaining soil fertility and a productive site, is so great that minor production problems should not interfere with the major objective of the commercial grower.

[6] M. A. Blake: Amount of Mulch Material Required by Apple Trees. Circular 286, New Jersey Agricultural Experiment Station, New Brunswick, N. J. June 1933.

Soil Conservation Service accomplishments as of June 30, 1939

Type of use	Planned for in cooperative agreements	Previous farm and ranch conditions	Increase
	Acres	*Acres*	*Percent*
Pasture and range	13, 546, 514	13, 034, 953	3. 9
Perennial hay land	567, 350	232, 883	143. 6
Cropland with winter protection, including cover crops and crop residues	2, 483, 434	1, 322, 559	87. 8
Erosion-resisting crops	1, 439, 754	1, 151, 660	25. 0

THE USE OF KUDZU ON CRITICAL SLOPES

By R. Y. BAILEY[1]

A critical slope protected by kudzu. The land, of moderate slope, was retained for row crops and the steeper portion above the corn was planted to kudzu in 1935. The kudzu is now in its fifth growing season.

ONE of the first steps in the development of soil-conservation programs was the division of slopes into classes and the formulation of land-use recommendations for each class. If each farm had contained the right proportion of land in each slope class, and if each field had been uniform in slope, the job of farm planning would have been simple. Under such ideal conditions, each field could have been converted to its proper use and given exactly the type of mechanical and vegetative protection that it required.

Under field conditions, however, it was found that the degree of slope varied within individual fields to such an extent that uniform treatment was not feasible. In many fields in the Southeast, areas of steep land occurred where normal treatment was inadequate. These areas were steep slopes usually flanked above and below by land of moderate slope that was needed for the production of clean-tilled crops. Obviously, where this slope condition existed it was not feasible to retire the entire field from cultivation.

On the other hand, where the steeper areas were terraced and cropped along with the land of moderate slope, terraces became silted, overtopped, and broken during heavy rains with serious damage to land lying below. The steeper areas had usually lost most of their topsoil and produced sparse growth of most of the crops planted on them. In many cases, the soil on these slopes was too poor and too badly eroded to produce sufficient growth of the annual close-growing crops ordinarily used to control erosion or to increase soil fertility.

In January 1937, these steep slopes of the Southeastern region were designated as "critical slopes" and special treatment with deep-rooted perennials, that would withstand drought and produce effective cover, was recommended for them. The name was accepted rather generally by farmers and agricultural leaders and was helpful to those working in the field in that it called attention to this particular slope condition. Soon after the name was applied field workers were looking for and recognizing these slopes, whereas in the past they had failed to notice them. This was very helpful in developing the power of observation and also in giving field workers a starting point in working out vegetative treatment for individual fields, particularly in the row-crop section where little protective vegetation had been grown previously.

Kudzu was one of the plants selected for use on critical slopes. This plant had been used extensively for many years as a shade around buildings, to a considerable extent as a gully-control plant, and to a

[1] Chief, regional agronomy division, Southeastern Region, Soil Conservation Service, Spartanburg, S. C.

limited extent for forage and grazing. Its use in cultivated fields had been very limited prior to the organization of the Soil Conservation Service, except in a few localities. At the time that it was first employed for erosion control in Service project and camp areas, most farmers were rather strongly prejudiced against it. They thought of it as an aggressive plant that would spread very rapidly and become a dangerous pest if planted near cultivated fields. Many of them had been told that if they allowed one plant to get started it would soon overrun the entire farm and make further cultivation impossible. Many technicians in the Service also considered kudzu a dangerous pest and were opposed to its use except in isolated gullies or hopelessly destroyed areas separated from cultivated land by roads, streams, or woods. Agronomists in the Service and at agricultural colleges, however, knew from direct experience with the plant that its habits of growth made it easy to control. They knew that, where kudzu was planted on land adjacent to cultivated areas, the plowing necessary for the production of row crops would prevent any undesirable spread to cultivated areas.

Farmers on whose land kudzu had been planted in 1935 and 1936 had learned that many of the stories concerning its aggressive habits were overdrawn, and they were willing by the spring of 1937 to allow its use on critical slopes through their best cultivated fields. This willingness was due in large measure to the fact that they had learned from experience that critical slope areas were expensive to maintain in cultivation and that their returns from such areas were far too low to justify the expense of cultivation. Many of them had also learned that the cost of terrace construction and maintenance was much greater on these areas than on adjoining land of moderate slope.

After a few farmers in each community planted kudzu on critical slopes through their cultivated fields, their neighbors decided that it was less dangerous than they had thought. The changed attitude toward kudzu is strikingly illustrated by the fact that of the approximately 40,000 acres planted in demonstration projects, C. C. C. camp areas, and soil conservation districts during the past 3 years, more than one-third was planted in strips through cultivated fields.

Kudzu is proving popular on critical slopes because it is a deep-rooted, perennial, deciduous vine that gives protection against erosion during the entire year. The dense growth of vines and foliage provides effective protection during the growing season and serves as a perfect first line of defense during heavy rains. In many instances where terraces above these strips have been broken during heavy rains, the flood water has been brought under complete control by the strip of kudzu lying below—flood water is relieved of its load of silt so that the terrace and the land below are protected from serious damage.

After the top growth of kudzu is killed by frost, the vines and dead leaves give complete surface protection during winter. When it is considered that stubble from a small grain crop, or a very light mulching of straw, reduces materially the amount of run-off it may be understood that a layer of leaves and vines 2 to 4 inches deep over the entire surface is of great benefit in reducing water loss. Except during periods of prolonged heavy rainfall, the run-off from an area that is well covered with kudzu is neligible.

In addition to the typical critical slope which lies between two areas of land of moderate slope, there are many other types of steep slopes that are being designated as critical slopes and given the same type of treatment. In many places the land on the upper part of a field slopes moderately down to a certain point from which the slope increases rapidly throughout the remainder of the field. Again, the upper part of a field may be very steep down to a certain point where there is a decrease in slope continuing throughout the remainder of its length. In either case, the portion of the slope that is considered too steep for the production of row crops is planted to kudzu.

On many farms there are long uniformly steep slopes that do not have sufficient acreage of moderately sloping cropland to produce the crops required on the farm. If all of such fields were planted to kudzu it would be impossible for farmers to produce the necessary row crops. If, on the other hand, the entire fields were kept in row crops, it would be only a question of time before the land became so completely destroyed that it could no longer be utilized for crop production.

These steep fields are being protected by planting every second or third terrace interval to kudzu. The intervals between the kudzu strips are used for row crops, with the fullest feasible use being made of close-growing annuals in the rotation. There is a distinct possibility that, after kudzu has become well established and produces a heavy cover for 2 or 3 years, it will be found feasible to develop a long-time rotation between kudzu and row crops.

Work along this line was started in the Dadeville, Ala., area in the spring of 1939. Two strips through

established stands of kudzu were disked, turned, and planted to corn. The growth of corn on these strips was excellent, and only one cultivation with the plow was necessary. If a satisfactory rotation system can be developed between kudzu and row crops, on fields of uniformly steep slopes, farmers can continue to utilize land that is generally considered entirely too steep for row-crop production. Such a rotation will make it possible for many farms to continue to support people indefinitely, whereas without proper treatment these farms are doomed to destructive erosion and abandonment.

In addition to its direct benefits for erosion control, kudzu produces forage that is needed on the farms. The lack of other sources of forage forces a large proportion of farmers to harvest vegetation grown in rotations that should be left for soil conservation and improvement. Observations made in a camp area in the Piedmont section of Alabama, in the fall of 1938, illustrate the importance of dependable sources of forage in connection with a soil conservation program. The farms in this camp area are small and the slopes are unusually steep. The urgent need for forage has caused farmers to cut the tops of corn above the ears for stover, to pull the fodder below the ear, and to cut the soybeans from between the hills of corn for hay. All these operations were done by hand labor, making labor costs unreasonably high. The land from which this expensive forage was stripped was left bare of vegetation and was therefore completely exposed to erosion during the winter months. A considerable portion of the 1,400 acres of kudzu planted on farms under agreement in this camp area is being harvested for hay during the summer and fall of 1939, and additional acreage will come into production each succeeding year.

Production of hay from kudzu will enable farmers to establish improved rotations wherein annual legumes and grasses may be used for soil conservation and improvement instead of being harvested for forage. The improved rotation will result in larger acre yields, and farmers can then plant a larger proportion of their steep land to perennial forage crops thereby further improving their conservation program.

Kudzu grown on critical slopes will also have an important effect on the pasture program in the Southeast. On a large number of farms the acreage of pasture is inadequate, and overgrazing becomes a serious problem during periods of summer drought. By enclosing strips of kudzu with temporary fence, a few weeks' grazing during dry periods will be permitted; this will prevent serious overgrazing of pastures and will maintain livestock in good condition. The increased amount of hay and grazing supplied by kudzu grown on critical slopes results in increased production of meat and milk for consumption on Southern farms.

Thus land formerly considered worthless for crop production and a plant once despised and neglected have been brought together by proper land use to provide the foundation for a sound vegetative program. The production of high-quality hay from low-quality land is enabling farmers to plan a better type of soil-conserving rotation on other portions of their farms. Results accomplished in the treatment of critical slopes with kudzu suggest limitless possibilities for the employment of other little-used plants in the development of a soil conservation program.

TENNESSEE COVERS THE SOIL FOR THE WINTER

By R. H. MORRISH [1]

TENNESSEE is conducting a carefully planned, methodical campaign to put agricultural lands under grass over winter. The movement is significant, for Tennessee has 4 million acres of row crops, most of them on highly erodible soils.

The need for the campaign dates back to the days of "When you see the smoke from your neighbor's chimney, it's time to move." When Virginians and Carolinians pushed their way past Cumberland Gap into the Wilderness, they found Indian tribes growing legumes, "also rye, oats, myllet, along with their corne." The settlers chose corn, and by the middle of the nineteenth century led the Nation in corn production.

Corn is a soil-depleting crop.

At the height of corn production, Solon Robinson, pioneer Indiana agriculturist and traveler, declared that "this land needs Bermuda grass, for this is a land

[1] Chief, regional agronomy division, Ohio Valley Region, Soil Conservation Service, Dayton, Ohio.

Turf oats and vetch seeded in cotton middles. B. T. Scruggs farm, Gibson County, Tenn.

of gullies." But tobacco came next and cotton, and today millions of Tennessee acres show the consequences. Some of them are gullied, some are completely destroyed and most of them are worn, for 50 inches of rainfall come down on Tennessee soils each year.

In 1935, H. S. Nichols, now assistant director of the Tennessee Agricultural Extension Service, and H. E. Hendricks, Extension agronomist, gave serious thought to the problem and started a winter cover crops campaign. When they surveyed the State, they found that very few farmers covered their land over winter. In the Highland Rim country and in east Tennessee, small grain was used. Franklin County used a large amount of crimson clover, but Franklin County had long been a producer of crimson clover seed. Nichols and Hendricks decided that more legumes, particularly crimson clover, would help greatly in solving Tennessee's serious erosion problem.

They found many obstacles. Late cotton picking was one and lack of adequate seed in certain counties was another. Farmers did not want to cut and shock their corn and disk under the stubble. It was apparent, very early, that the campaign must be on a community basis and that a comprehensive cover crop program called for a large organization. Through county agricultural agents all agencies directly or indirectly concerned with land use were asked to help and county meetings discussed and planned action programs for the solution of major problems confronting each community. The county meetings were followed by community meetings where the ultimate goal was attained, for here the farmers came in large numbers, saw the seriousness of the problem and agreed to put their land under cover.

These community meetings were headed by the county agricultural agents supplemented by specialists of the Extension Service, Soil Conservation Service, T. V. A., the experiment station and college of agriculture, and the A. A. A. Instead of meeting in courthouses or schoolrooms, the groups went to demonstration farms set up by the Extension Service in cooperation with the T. V. A. There they saw for themselves the advantages of crimson clover and vetch and Austrian winter peas. Nearly 900 of these

(*Continued on p. 54*)

BERMUDA—ONE-TIME PEST—NOW A SOUTHERN FAVORITE

By EDGAR A. HODSON [1]

IN Australia it is known as couch grass. In California where its aggressiveness has been feared, it is called devil grass. Virginia farmers recognize its tenacity; they call it wire grass. In other places it is dogtooth grass, Bahama grass, Scotch grass. But throughout Arkansas, Louisiana, Texas, and Oklahoma, the farmers call it Bermuda.

Happily, the mass of Southern and Southwestern farmers are beginning to realize what a few have known for a long time—that Bermuda provides profitable utilization of eroded land; that it is one of the most effective base pasture grasses yet introduced in the South; that it is one of the best all-around erosion control plants ever used in the South and that it is an excellent soil builder.

Conservation farmers throughout this region have taken a cue from men like Harry Kelly who brought a shoe-box full of Bermuda, from Missouri, to his farm near Fort Smith on the Arkansas River in 1887 (he now has 2,000 acres in Bermuda), and F. A. Mitchell, "Father of Bermuda," in Oklahoma. They have cast aside their prejudices against this grass. They have learned to make it serve them instead of regarding it as a pest simply because they heretofore have not seriously considered methods of controlling it.

Fortunately, this new concept of the value of Bermuda grass in the average farming enterprise is based on a realization that grass is a profitable crop and as such deserves the same attention and consideration as any other crop regarded as an integral part of the farm program.

Regarded in this light, grass is no longer considered as an expedient for a specific purpose such as the treatment of land so badly eroded that it can be used for nothing else. A belief that grass may occupy land as good as that occupied by any other crop means that grass once more is coming into its rightful place on the farm. The fact that grass also cures gullies, serves to improve pastures, stabilize eroded areas and protect watersheds follows as a matter of course when it is given an equitable share of the land in the average farm. In Region 4, Bermuda grass has been accorded an important place in the farm program and is being used to perform a dozen needed jobs on the farm.

Bermuda grass thrives well in the four States of the region, as far west as the line marking the beginning of the belt which receives less than 25 inches of annual rainfall.

Of first importance is the fact that Bermuda is one of the most effective plants known for use as a base pasture grass throughout most of the region. Its forage value compares favorably with other pasture grasses but has the disadvantage of providing limited grazing during any hot, dry period in the summer and practically no grazing during the dormant season of winter. But this disadvantage has been mitigated in Region 4 by the overseeding of Bermuda pastures with adaptable legumes such as lespedeza, hop clover, white Dutch clover and bur-clover. This practice tends to lengthen the grazing season and to give the pasture the benefit of the soil-building properties of the legume.

Since Bermuda is readily established on most soils in the region and is a good forage plant, its value in an erosion control program cannot be overemphasized. Where care is exercised in the sodding operations, a good stand of the grass can be obtained within a year's time on most farms in this region.

Results obtained from the cultivation of Bermuda sod, in the establishment of new pasture areas, definitely prove the value of the practice. Survival in most instances has been satisfactory, and the spread of the grass has varied with the different methods of sodding used and the treatment given. On areas where there was no soil preparation and where the sod had not been cultivated, the spread of grass usually was very slow. Where the land was prepared by flat-breaking before the sodding, or the grass sodded with a cultivated crop, an excellent growth and spread of the grass was secured. A rapid spread and growth of grass has been obtained from sod placed in the rows at corn-planting time. The cultivation given the corn keeps down noxious weeds and grasses, scatters the sod, and provides a soil condition favorable to the spread of Bermuda.

If Bermuda is to be sodded with a cultivated crop a tall-growing plant, with foliage that is not too dense, should be used so that the grass will not be shaded out.

Bermuda also is being used extensively in Service demonstration areas and in soil-conservation districts for individual terrace outlets, terrace outlet channels, meadows, gully control, stabilization of eroded areas about the farm for the establishment of wildlife

[1] Chief, regional agronomy division, Western Gulf Region, Soil Conservation Service, Fort Worth, Tex.

A Bermuda grass meadow on the farm of C. T. Douglas, Guy, Ark., which utilizes idle land, provides a safe area on which terrace water from the adjoining field can be outletted, and furnishes an excellent hay crop.

habitats, revegetation of existing pasture areas, and roadside erosion control.

In addition to controlling erosion, the use of Bermuda grass for a variety of purposes has resulted in profitable utilization of the land which the grass protects. The establishment of pastures on land which could not be profitably utilized for other crops has given the farmer additional pasture. Bermuda meadows have been established on land formerly permitted to lie idle, such as natural drains grown up in weeds and sprouts, and other odd corners about the farm. This practice has provided erosion control, protected areas on which terrace water can be outletted, and furnished an extra hay crop.

The fencing of terrace outlet channels has made it possible for them to be used as pasture where pasture areas are adjacent to the channel or can be connected with the channel. This practice keeps down weeds which may compete with the grass and provides economical and practical maintenance of the channel.

The old fear that Bermuda, once given a foothold, will spread into the fields, choke out the crops and generally overrun the farm, is being allayed by simple control methods. The method most widely used is that of planting border strips around fields next to Bermuda grass pastures, meadows or channels, so that the plants in the border can serve as a balk to stop the Bermuda before it reaches the field.

But the experience of farmers and their own revised attitude toward Bermuda is the most convincing proof of the new light in which this grass is regarded in the South today.

There is, for example, the experience of the Brantley brothers, Jesse and John, of Farmerville, La. The adjoining Brantley farms are located on a slope, Jesse's on the top of the hill and John's at the lower end of the slope. When conservation systems were established on these farms in 1935, a joint terrace outlet channel was planned. Jesse readily agreed to the establishment of a channel sodded to Bermuda grass, but John refused to permit the use of this grass on his half of the channel. Hence that part of the channel on the Jesse Brantley farm was economically established by excavating for the channel and sodding with Bermuda, while that part on the John Brantley farm was protected with expensive concrete structures. During the winter of 1935 and 1936 John noticed that his channel was scouring badly and that silt was being deposited on his pasture while the Bermuda channel on Jesse Brantley's farm was performing perfectly. Thus it was that in the spring of 1936 John Brantley requested Service technicians from the Farmerville project to help him remove the concrete structures and sod the channel with Bermuda.

"I objected to Bermuda in the outlet channel because I thought it would spread into my fields. After trying concrete spreaders in the channel I learned that the most practical control method is Bermuda grass. I work my fields the same as I did before and I haven't noticed any Bermuda in them since I sodded it in the outlet channel." Thus John Brantley now defends the grass he once refused to have on his farm.

Noah Deering, progressive farmer of Harrison, Ark., said recently that a 22-acre Bermuda grass and lespedeza

pasture (established 2 years ago) this year returned him $396 in the form of weight gains made by 22 steers that have grazed the pasture.

He said that the 22-acre pasture furnishes sufficient forage to support 22 head of steers 6½ months of each year, and that their average weight gain during this period is 300 pounds. Based on a price of 6 to 7 cents per pound received when he sold his steers, Mr. Deering figures that the pasture paid him $18 an acre this year.

"A few years before I established this pasture I planted the 22 acres in oats but did not harvest enough to pay me for the seed I put out," he said.

R. L. Folts of Greenbrier, Ark., in the Conway project area, gives credit to Bermuda, lespedeza, and hop clover for doubling the carrying capacity of his pasture. "A 42-acre pasture, which 3 years ago did not furnish sufficient forage for 6 head of livestock, now carries 13 head with ease," Mr. Folts said. "And this pasture which was sodded with Bermuda and overseeded with lespedeza and hop clover is capable of supporting 25 animals."

Alfred Ballman of Riesel (near Waco, Tex.) found a profitable use for 11 acres of idle land when he converted the area to permanent Bermuda grass pasture. "This idle area, situated along a natural drain, was too wet for use in cultivated crops. It was cleared and sodded to Bermuda and now furnishes forage for my livestock as well as a protected area on which I can outlet terrace water," he stated.

These examples could be multiplied many times over, since they represent a cross section of farmer opinion on Bermuda in Region 4.

Probably of equal significance in this trend toward grass consciousness in agriculture is the fact that many conservation farmers in this region are now considering the use of Bermuda grass in a long-time crop rotation—resting cultivated land with grass.

TENNESSEE COVERS THE SOIL

(*Continued from p. 51*)

community gatherings were held in one summer, with an attendance of more than 30,000 farmers.

At the end of the first campaign in 1935, 520,000 acres were covered up over winter, mostly with small grains. In 1936 there was a serious set-back, when drought hit hard and many seedlings failed; but an intensive drive was made to include more legumes in the rotation and by 1937 the acreage protected had soared over the million mark, a fourth of which was in winter legumes. The program has made progress through the years.

Even more valuable than the actual protection to the soil is the fact that farmers understand the value of lime and phosphate materials, how the different cover crops can be utilized to build the land and at the same time increase their farm income, and how to guard against erosion. Alfalfa acreage has more than doubled in 6 years.

From a study made of the production of over 2,000 livestock farmers, it was apparent that the weakest link in the pasture program in Tennessee was winter pastures. At the present over 100 days of extra grazing are being obtained by farmers who are using cover crops. The majority of these demonstrators use crimson clover as the base of winter pasture.

The 1939 goal is 2,000,000 acres—half of the row-crop acreage—and Nichols and Hendricks are confident that it will be attained. Indications are that the largest acreage ever seeded to winter cover crops in Tennessee will be sown as a result of this State-wide campaign. Nor are other soil conserving practices being neglected at the community meetings; the effects of close-growing sod crops, properly constructed terraces, strip cropping, contour furrowing, pasture improvement, contour tillage and other conservation farming practices widely adapted by farmers are being emphasized. Tennessee plans to go into the next winter under cover.

Like other States, Tennessee is approaching its problem from the community standpoint. Its extension education has long been through the community approach. Two years ago, G. S. Hollingsworth, extension soil conservationist, chose 10 communities as proving grounds and today it can be said that hope has returned to residents of these communities through demonstration projects. Once discouraged and ready to cease trying to earn a living from badly eroded lands, farmers have taken new heart. They are using winter cover crops, they are building terraces, and even the women help in building check dams and assist in planting trees. The county agents and the home demonstration agents will tell you that the community organizations have improved farm morale.

Farmers in Madison County scarcely knew the meaning of winter cover crops when the Service began operations through a C. C. C. camp in 1935. Whereas only 30 acres on farms cooperating with the Service were so protected then, today well over 2,000 acres on such farms are in bur-clover and crimson clover, Italian ryegrass and vetch, during the winter months.

PROTECTED WATERWAYS

By HARRY H. GARDNER [1]

Grassed waterway on farm near McGregor, Iowa. Typical of the well-maintained waterways in this area.

WATERWAYS trace the pattern of erosion on the landscape. They trace, too, the physical outlines of erosion control. When a watershed "cracks up" through erosion, the cracks run along flowage lines. As erosion takes its toll of soil and fertility, the network of flowages, branching out from the central stream to every part of the drainage area, marks the patchwork of watershed disintegration. Gullies reach out from the central stream, eat through depressions where run-off concentrates, cut back finally through upland fields. Along these open wounds runs the lifeblood of the farms—liquified topsoil, mobile under the lash of rain. Thus, in a very real sense, erosion control is watershed control.

Logically, the focal points of our erosion attack are along these drainages where run-off concentrates. The control problem is intensified where surplus water piles up and speeds downward, and here the effectiveness of control work is most accurately measured. Our entire control program—changed land-use patterns, correct crop rotations, contour tillage, strip cropping, and the rest—can be defined fairly accurately in terms of waterway protection, for the upland control measures keep run-off and siltation through drainageways at a minimum. The upland practices reinforce the control measures applied at the points where run-off concentrates.

[1] Chief, regional agronomy division, Upper Mississippi Region, Soil Conservation Service, Milwaukee, Wis.

The objective is to develop the waterways into safe transportation systems for suplus rains—to lead run-off from ridge to river with a minimum of damage along the way. This involves all possible means of protecting the waterways, normally with vegetation—trees or grass.

Agronomists in the Upper Mississippi region have placed great emphasis on the development of grassed waterways in connection with contour tillage, strip cropping and terracing. In each farm plan, conservationists have stressed complete protection of upland drainages, to prevent cutting through contoured rows or strips.

Both seeding and sodding have been used in establishing protection against surplus rain—sodding where time is an important factor, seeding where time is of less consequence. Sodding has been extensively used in Service projects and camp areas because of the need to establish effective demonstrations as quickly as possible. It is realized, however, that most farmers will use the seeding method, and in fact a number of excellent waterway seeding demonstrations already have been developed.

Bluegrass sod has been used exclusively for sodding purposes and in most instances for waterway seeding. Generally, sodding is confined to small areas because of the labor involved in cutting, moving, and laying sod strips. In many areas a combination of sodding and seeding is the chosen method. Where a large

amount of sod is needed a sod cutter is used, either the sled type or the rolling colter with the latter preferred. Pulled by team, tractor, or truck, this equipment will cut from 200 to 400 square yards of sod per hour.

The importance of setting the undercutting knife to obtain thin slices of sod cannot be overstressed; for average conditions the strips should be approximately 1½ inches thick, though in very dry periods they may be somewhat thicker. Sod more than 1½ inches thick cannot be easily rolled and is more difficult to lay because dirt is knocked off from the longer roots during transportation, and this makes the bottom of the strip uneven. The thinner strips establish themselves more readily because more roots are found in the upper level immediately below the crowns of the plants; also a thin sod responds more readily to tamping and makes a better contact with the soil. Wire netting is generally used to hold the sod in place while it becomes established.

Where sod is to be laid on subsoil as in eroded areas or in constructed terrace outlets, fertilizer, and lime if it is needed, should be first applied. Good barnyard manure is often used effectively.

Seeding mixtures for waterways vary so widely among different localities that no general recommendations can be made. Bluegrass with timothy and shallow-rooted legumes form common seeding mixtures in Wisconsin, Minnesota, Iowa, northern Illinois, and northern Missouri. Such a seeding eventually results in the formation of bluegrass sod. In southern Illinois and southern Missouri, redtop is seeded in a mixture with timothy, lespedeza, and alsike. In wet or poorly drained spots, reed canary grass is often sown; and sometimes plugs of slough-grass (*Spartina pectinata*) are dibbled into such soils. Of course the purpose of all mixtures is to provide effective protection while the dominant species becomes established.

Deep-rooted legumes such as alfalfa are not recommended for use in waterways because of their tendency to bunch—they do not provide sufficient protection as they cause concentration of run-off within the waterway during periods of heavy rain.

As to the relative value of seeding and sodding, agronomists in the Upper Mississippi region are often heard to say, "In terrace outlets use sod and sometimes seed; in natural waterways use seed and sometimes sod."

As soil conservation districts assume leadership in erosion-control work it is probable that the tendency will be toward increased seeding rather than sodding of waterways and no doubt even terrace outlets wil be prepared by seeding in the district areas.

The protected waterway should be wide enough to care for all the water likely to come down it—and this is emphasized because often the protected area proves too narrow to be effective. Widths vary from 20 to 100 feet, depending on the amount of water to be carried and the steepness of slopes on both sides of the waterway. The grass should extend well back over the shoulders of the natural depression or the constructed outlet, as otherwise gullies are likely to form at the edges and the farmer will be troubled with two gullies where he had one before. As further protection against gully formation, the edges of the grassed area should be uneven, with numerous bulges and recessions, so that water will not flow straight down them.

Proper maintenance of the waterways is of course essential to their continued effectiveness. They should always be crossed at right angles when the fields are being plowed or cultivated. Equipment should be raised at the edge of the protected strip and set down only when the other side is reached. Waterways should be carefully inspected after every heavy rain so that weak places and washes may be repaired before serious damage is done. Thinning or weakening of the bluegrass stand almost always is evidence of depleted soil fertility, for which the obvious cure is a well distributed application of barnyard manure.

Grassed waterways cannot properly be considered wasteland. They may be used as convenient turning places during field operations, and they often provide good pasture—in many instances the hay grown on them is the best hay on the entire farm. But the chief purpose of waterway protection is to control erosion, and all other uses should be subordinated to this one. A dense sod is necessary to prevent washing, and to form a dense sod grass must be watered and fed.

Bluegrass should be clipped often enough each year to prevent seed formation and weed growth. Long grass lops over and catches silt, building up the channel unevenly and often diverting the course of the water. It should not be grazed during the hot, dry, summer months which form its dormant period, and grazing should cease early enough in the fall to enable the plants to store up reserve food for vigorous early spring growth. On waterways of any type, whether bluegrass or timothy, mowing is preferable to grazing, but the areas can be grazed without damage provided precautions are taken against overgrazing and against grazing in wet weather.

Thus managed, grassed waterways can do double duty for an indefinite period of time—produce feed for livestock and serve to protect the farm from deep gullies.

PROGRESS OF REGRASSING IN SOUTHERN GREAT PLAINS

By SIDNEY H. WATSON [1]

A combination grass and cover-crop disk drill fabricated by equipping a standard grain drill with combination corn and cotton boxes. Note the large seed tubes required for planting fluffy native grass seed.

OF THE 50 million acres of cultivated land in the southern Great Plains region, approximately 6 million are unsuited for cultivation and should eventually be retired to permanent vegetation. About a million acres of the crop lands are suffering severe wind erosion and should be retired to grass immediately; much of this land has been abandoned and is now a serious erosion hazard to adjoining lands. In addition to the cultivated land approximately 2 million acres of denuded range lands are in need of revegetation.

The need for adapted grasses for revegetation work in the Plains long has been recognized by leading scientists who have studied the existing problems. Probably the first experimental work on grasses adapted for revegetation under Plains conditions was initiated at the Department of Agriculture Grass Experiment Station at Garden City, Kans., in 1889. This work was expanded in 1890 and continued until 1892, when "on account of the reduction in the appropriation the Department was under the necessity of discontinuing the assistance afforded to state experiment stations in the prosecution of grass experiments, except in the case of the three States of Georgia, Mississippi, and Louisiana." Several native grasses including *Panicum virgatum*, *Andropogon hallii*, *Andropogon provincialis*, and *Andropogon scoparius* were included in these early studies.[2] Had this work been continued without interruption, no doubt many of the perplexing revegetation problems of today would long since have been solved.

As a result of land misuse, drought, and accompanying economic stress in the so-called Dust Bowl, in recent years it has become increasingly important that bad "blow lands" be revegetated to assist in arresting "black blizzards" and to bring about a more stable agriculture. State and Federal agencies have joined forces to perfect technique, while farmers cooperating with the Soil Conservation Service and other action agencies have worked with enthusiasm to establish a revegetation program.

Results of revegetation work by the Service have not been universally satisfactory, due in part to insufficient factual data and to drought conditions of recent years. In widely scattered areas of the southern Plains, farmers, in cooperation with the Service, had developed conservation practices demanding that large acreages "go back" to grass, and with this need in view seed of the native grasses once so abundant throughout the Plains were collected and planted. Some field plantings were successful; others were not.

Recognizing that more factual revegetation data were needed and that a concerted effort of all agencies was necessary, in January 1939 representatives of State and Federal agencies met in Amarillo, Tex., and outlined a plan for a further coordinated attack on the problem. This plan called for expansion of the work of the Bureau of Plant Industry, State agricultural experiment stations, and the Soil Conservation Service, and for close cooperation of these and other agencies in all phases of the work.

The Bureau of Plant Industry and the State Agricultural Experiment Stations agreed to expand their grass research programs as rapidly as possible. In addition to basic information pertaining to adaptation and methods of establishment, these agencies are conducting an intensive grass breeding and selection program and are assisting the Service in developing plans for evaluation studies, field trial plantings, and research projects, and are advising with regional operations technicians as to procedures to be followed in work units.

The Service also agreed to expand field operations—to purchase special equipment for revegetation operations, to carry on research work to the extent of its facilities, and to collect seed of native grasses for plant-

[1] In charge, revegetation program, Southern Great Plains Region, Soil Conservation Service, Amarillo, Tex.

[2] See report of the Secretary of Agriculture, 1892.

ing. Intensive studies are now under way at Amarillo and Dalhart, Tex., and at Cheyenne Wells, Colo. Nursery field trial plantings have been increased and in the spring of 1939 field operations were greatly expanded.

It was realized that grass seed broadcasted by hand had not given results comparable with those from drilling. Regular seeding equipment is not suitable for planting many of the native grasses, and with this in mind the State experiment stations, the Bureau of Plant Industry, and the Service have been working together to develop special drills for satisfactory seeding of native grasses as well as sorghums and small grains used for cover.

It was found that cotton boxes are very satisfactory for seeding most grasses, and using this finding as a basis, the Service developed specifications for use by implement dealers in fabricating the drills now in operation in this region.

The disk type drill will operate successfully in almost any type of cover, including large weeds and unharvested sorghums. It consists of a regular grain-drill frame equipped with combination corn and cotton boxes spaced 12 inches apart, specially constructed large seed tubes, furrow openers, and press wheels. With a variable speed transmission and cotton plates with varying numbers of seed openings, any desired rate of seeding can be made. Three types of furrow openers are used, depending upon soil and cover conditions: namely, the 18-inch single disk, the 18-inch double disk, and coulters and shoes.

Shovel-type drills are satisfactory for seeding on stubble land where soil blowing is not a serious problem. From the standpoint of moisture conservation, shovel openers are more desirable than other types even though some disadvantages are involved, such as destruction of cover, filling in of furrows which cover seed too deeply, and a seedbed not sufficiently firm. These disadvantages have been overcome in part, however, by the use of divided seed tubes, on a specially constructed drill, which place seed in the sides of furrows rather than in the bottom. This drill was fabricated by setting cotton boxes at 20-inch centers on a lister frame. By the means of the Y-seed-tube, seed is placed in the sides of 7-inch furrows giving an alternate drill spacing of 7″–13″–7″. The drill is also equipped with V-shaped rubber-covered press wheels, which aid in covering seed and firming the soil.

The first step in revegetation in areas subject to wind erosion is to prevent soil blowing while grasses are becoming established. Cover crops, including sorghums and small grains, are used extensively for this purpose. Drilling of sorghum in close-spaced rows of 12 to 20 inches affords the most satisfactory cover. Where conditions are not too critical, crops may be harvested to leave a 12- to 18-inch stubble although in many instances it is necessary to leave practically all forage on the ground to provide adequate protection against soil movement and to improve the physical condition of the soil. Mowing and leaving residue on the ground seems preferable to leaving the crop uncut, and this is particularly important if seed is produced by cover crop, as volunteer growth competes with grass seedings. Where severe soil blowing has occurred, it is impossible, in most cases, to establish adequate cover for grass planting in one year. Two or three years, or even longer, will be required to bring about satisfactory conditions for grass seeding.

Many fields where revegetation must be attempted are badly hummocked, and it is necessary to level the hummocks before a uniform stand of cover crop or grass can be expected. Where hummocks are small a lister is satisfactory for leveling, but often they are so large that a grader is required. The conservation of all available moisture greatly increases the chances of establishing both cover crops and grass. Contour tillage and seeding operations are essential for the best distribution and utilization of moisture on most soil types. Since close-drilled cover crops afford the best cover for grass seeding, these crops might best be planted with a shovel-type drill. Where two or more years are required to obtain satisfactory conditions for grass seeding, it may be advisable to plant the cover crops in lister rows, at least the first year.

Various experimental results show the value of mulch in conserving soil moisture and, of course, its value in preventing wind erosion is well known. In establishing grass on the more critical areas it may be necessary to resort to this practice, and, if so, the more crop residues left on the soil the better are the chances for establishing grass.

Weeds cannot be overlooked as a possibility in providing ground cover for initial stabilization and to produce a more favorable physical condition of the soil. The seeding of grass in growing weeds or in other growing crops is not generally recommended. With additional studies, however, it may be possible to develop methods of handling weeds whereby this natural cover can be successfully utilized for grass planting. It has been found that weeds, especially Russian thistle, mowed while still growing, will remain on the soil and afford protection against blowing, whereas if left uncut they often break off at the ground, leaving the soil bare and subject to erosion.

It has long been recognized that a firm seedbed is essential to the establishment of grass, and this point cannot be overemphasized. Often it is necessary to firm the soil with some type of land packer before or after grass is seeded.

Most native grasses must not be covered too deeply. On heavy soil the best emergence is obtained when they are covered to a depth of one-fourth to one-half inch, but on sandy soil they may be covered somewhat deeper.

Native grasses which are being used most extensively are *Bouteloua gracilis* (blue grama), *B. curtipendula* (side-oats grama), *Andropogon hallii* (western bluestem), *A. scoparius* (little bluestem), *Agropyron smithii* (western wheat), and *Buchloe dactyloides* (buffalo). Seed of most of these grasses may be harvested with combines, or hay containing seed may be scattered over areas to be revegetated.

All revegetation problems of the southern Great Plains will not be solved immediately, but definite progress is being made through the cooperative efforts of all interested agencies.

CRESTED WHEATGRASS ON DENUDED RANGE AND "GO-BACK" LAND

By WILKIE COLLINS, Jr.[1]

IN THE northern Great Plains region—North Dakota, South Dakota, Montana, Wyoming, and Nebraska—millions of acres of land are lying idle while no economic return is being derived from them. This condition was brought about by the subjection of large acreages of low-rainfall areas to the plow. Several good crops were produced after the native sod was turned under, but as the fibrous grass roots began to decay the structure of the soil began to break down and its organic matter and absorptive capacity decreased rapidly. The limited rainfall of the area which had permitted frequent plentiful crops of small grain no longer seemed sufficient for a permanent dry-land agriculture. The consequences are well known: Years of low rainfall, prevalent grasshopper infestations and high wind velocity left in their wake crop failures and drought stricken conditions and, in localized areas, a people with a badly shaken morale. Hundreds of farms were abandoned and millions of acres allowed to remain idle and unprotected from the ravages of wind erosion.

One of the important tasks of the Service in these areas is to demonstrate how the soil can be returned to proper land use and economic productiveness by the growing of adapted perennial grasses in a way similar to that of nature in the plains country. The use of proper grass species, proper rate, date and method of seeding idle lands, has been successfully demonstrated. During the past year, approximately 80,000 acres of perennial grasses were seeded on land utilization projects with a relatively high degree of success.

In general, grassland that has never been broken does not need reseeding. Such an area usually can be brought back to a productive state if grazing is restricted so that the sparse stand of grass may reproduce vegetatively and from seed when rainfall permits. Where the native vegetation is completely killed out, the practice of drilling the area to a grass-legume mixture, using a deep-furrow drill operated on the contour has been used. If the acreage is small on the individual farm, the denuded area is plowed in strips, the strip is cropped to small grain for one year and the grass seed is drilled in the small grain stubble late in the fall, with the intervening strips treated in a

[1] Agronomist, regional agronomy division, Northern Great Plains Region, Soil Conservation Service, Lincoln, Nebr.,

A field of crested wheatgrass in Montana. It was seeded in the fall of 1935.

similar manner the following year. The acreage of denuded range land that has been seeded is very small and consequently is discussed but briefly.

Before the Service started making recommendations and working out definite conservation plans on idle lands, a very careful and detailed study was made at the State experiment stations and Federal dry-land experiment stations to determine what grasses were proving most successful. Leading farmers and agriculturists in the various States were interviewed, and the agricultural workers of western Canadian Prairie Provinces were questioned in the effort to learn what grasses were proving most successful in their work and what methods of establishment were producing the best results. In addition to these investigations, a soil conservation nursery was set up in order to try out the various grass species and make determinations relative to adaptability and seeding technique.

A study of the collected information indicated very definitely that crested wheatgrass (*Agropyron cristatum*) is one of the outstanding grasses adapted to the northern Great Plains. Since it is a long-lived perennial bunch grass, crested wheatgrass has an extensive root system, is very drought-resistant, is a good weed fighter and is capable of going into a dormant stage during extremely dry weather. In addition, it is an early grass, producing palatable forage with a relatively high protein content and large quantities of viable seed that is easily harvested.

Grazing tests conducted for 20 years on the Ardmore Experiment Station, South Dakota, indicate that crested wheatgrass is very hardy and has approximately two and one-half times the carrying capacity of native grass species. The experiment stations at Archer, Gillette, and Sheridan, Wyo., have been successfully establishing crested wheatgrass for several years and grazing tests indicate high carrying capacity. Work with this grass at the Moccasin and Havre Experiment Stations, in Montana, have been outstanding: At Moccasin grazing tests indicated crested wheatgrass as superior to all other adapted grasses. On the northern Great Plains Field Station at Mandan, N. Dak., John Sarvis has worked with crested wheatgrass for more than 20 years. At the experiment station at Dickinson, N. Dak., Leroy Moomaw has had very successful results in his work with the grass. The results obtained in Canada were also very satisfactory, and many of the agricultural workers are enthusiastic about the results to be obtained from its use.

Even though crested wheatgrass was introduced into this country in 1898 from the cold, dry plains of Russia and Siberia, it had not attracted wide attention among commercial seedsmen of the northern Great Plains and available seed was not very plentiful. However, backed by the unusual success at the experiment stations, the Service decided to use crested wheatgrass as the principal grass in the program for the restoration of large acreages of idle lands.

The seeding of "go-back" or idle lands has now progressed sufficiently for technicians to recognize the merits and justify the confidence placed in crested wheat. The species used in the regrassing program have varied considerably with soil type, amount of precipitation, degree of erosion, kind and amount of vegetative cover, and the use to be made of the grasses.

In general, with the exception of the eastern one-third of South Dakota and the eastern half of Nebraska, and on irrigated lands, crested wheatgrass has constituted at least 50 percent of the grass mixture used in seeding abandoned lands. In practically all instances mixtures have been used, with a sod-forming grass such as western wheatgrass (*Agropyron smithii*) or smooth bromegrass (*Bromus inermis*) being added to the crested wheatgrass. In many cases a small quantity of white sweetclover (*Melilotus alba*) or alfalfa (*Medicago sativa*), depending on soil type, has been added to the mixture to increase the value of forage and add nitrogen to the soil. In adapted areas, crested wheatgrass has proved the most reliable grass seeded and about the easiest to establish. A common mixture used in reseeding idle land is 3 pounds of crested wheatgrass, 2 pounds of western wheatgrass, and 1 pound of yellow blossom sweetlcover per acre. This mixture has produced good results. However, in many instances 4 pounds of crested wheatgrass was used with 1 pound of western wheatgrass.

The most satisfactory seeding has been done with the small grain drill and using a grass seeder attachment for the clover. When the grass is to be drilled on the contour or in heavy stubble or on a weedy field, the single-disk, deep-furrow drill is recommended, as it will leave a larger furrow for moisture-conservation purposes. In light-textured soils or completely barren soils, however, the deep-furrow drill is not recommended as soil drifting will often cause the seed to be covered too deeply. The broadcast method is not used in the drier areas because the seed will germinate and then die after the soil has dried out underneath the seedling.

The date of seeding is very important, and as crested wheatgrass is a native cold-weather plant, many stands

(Continued on p. 63)

THE ROLE OF RESEEDING IN RESTORING SOUTHWESTERN RANGES

By EVAN FLORY [1]

Two and a half years before this picture was taken, this site was crisscrossed by a gully. Reseeding and protection from excessive grazing resulted in this luxuriant stand of western wheatgrass, crested wheatgrass, and sweetclover. Vegetation took a good hold and stopped active cutting.

TOO heavy utilization in the past of vast range resources, together with climatic limitations, has depleted the vegetative cover and set the stage for progressive man-made erosion in the Southwest.

As the more desirable forage species disappeared, the land was left partly denuded and partly covered by species of low erosion-control value often poisonous to livestock. With decreased density of cover came increased run-off with subsequent sheet erosion, gullying, head cutting, and wind erosion.

Rehabilitation of range lands depends largely upon natural revegetation through proper range-management practices. But depletion has proceeded so far in many localities that artificial means are needed to establish a vegetative cover so that erosion processes can be checked before soil conditions become altered to such an extent that revegetation is no longer possible. This is important, because the effectiveness of other conservation practices depends on an adequate ground cover.

The Southwest region is a land of extreme conditions. Annual precipitation varies from 3 to 40 inches. Growing seasons range from 30 to 365 days. Elevations range from 137 to 14,000 feet above sea level. In some parts of the region, annual precipitation comes largely as winter snow; in others, it is rather evenly distributed between winter and summer; and in some areas it is limited largely to late summer.

In response to these conditions, plant associations in the Desert Scrub, Sagebrush, Woodland, Prairie, Montane Forest, Subalpine Forest, Boreal Forest, and Tundra formations are encountered. Our major problem areas, however, are characterized by a long, dry period that lasts from early spring to July, often into August. Hence, the major limiting factor in our revegetation program is soil moisture.

Years of experience by the Forest Service, and later by the Soil Conservation Service show that it is a waste of time and money to attempt revegetation unless the grazing practices which caused depletion in the beginning are corrected. No attempt is made at artificial revegetation in solid blocks, or where stock concentrate, unless the management plan provides protection for young seedlings against grazing and trampling damages until they will withstand normal usage. Under most of our conditions, this requires two growing seasons, with use the year or two following limited where possible to the dormant period.

In the bunchgrass and wheatgrass associations in Utah and northern Colorado, with winter rainfall prevailing and where dry farming has been practiced, soil moisture is generally adequate for successful artificial revegetation by solid seedings. Ordinary preparation of soil for dry farm seeding operations is commonly satisfactory, but augmenting normal soil moisture by conservation methods increases the chances of success and yields.

[1] Range examiner, Southwest Region, Soil Conservation Service, Albuquerque, N. Mex.

In areas characterized by the grama association and summer rainfall, additional soil moisture provided by means of furrows, ditches, dykes, terraces, ridges, percolators, spreaders, etc., aid materially in establishing a stand.

Litter has been very beneficial in facilitating establishment of young seedlings in the more arid locations, by shading them from direct light and protecting them from direct wind. Straw containing much seed has been used effectively on dams, stock tanks, dykes, and other exposed areas; it is an expensive practice, however, that can be justified only on critical areas.

On range seedings proper, in the Pecos River section of the region, litter may be furnished by Sudan grass, cane or a similar annual crop planted the year previous to grass seeding. It should be a crop that will not reseed to compete with the grass seedlings.

We are fortunate in this region in that desirable pioneer grasses will succeed on the most eroded phases of many soil types. The inclusion of some climax species seed in the mixture provides scattered individual plants to furnish a well distributed seed supply for the whole area while the pioneer species create conditions favorable to succession toward the climax.

Introducing an efficient legume helps to improve both grassland and soil. Legumes commonly are excellent pioneers. To improve range and soil they must be essentially herbaceous, edible and palatable, aggressive and able to withstand grazing. Much work remains to be done in locating, selecting, and introducing desirable legumes.

We have found that seed mixtures are better than one species used alone because grasses vary in seasonal requirements, soil needs, rapidity of establishment, and persistency of stand. Consequently, a suitable mixture will bring a quicker stand, a more permanent cover, and higher yield than will any one species used alone.

The proportion of seeds of each species to be used in a mixture is based upon the proportion of individuals that usually survive establishment and competition between young plants. It is a waste of seed to sow small amounts of a weak species with large or equal amounts of a strong species. Recognition of these principles in the preparation of a seed mixture will satisfy the requirements of plant succession on areas of varying degrees of depletion.

We find that nurse crops use moisture badly needed by young grass seedlings and therefore we do not use them.

Time of seeding varies considerably in various parts of the region. Where precipitation is largely from late summer rains, seeding just before the rainy season is most desirable. But in areas with the major portion of the year's precipitation in the form of snow and early spring rains, seeding just before winter sets in has proved best.

Areas dominated by gramas, galleta, tobosa, and associated species generally are seeded best in late summer, as they need high temperatures for ready germination. Such areas usually have slight winter and spring precipitation and a very dry early summer with rains beginning in July. Ordinarily it is possible to begin seeding in the latter part of June, if a large seeding program is contemplated.

Areas dominated by bunchgrass and wheatgrasses are seeded best in late fall or early spring, as these species will germinate readily in rather cool weather. Moisture conditions are also most satisfactory at this period, since this habitat has relatively high winter and early spring precipitation with dry summers. Late fall is preferable to early spring planting, because the seed will remain dormant in the soil during the winter and will germinate on the first warm days in the spring while the soil is still moist from melting snows.

The amount of seed used in artificial range revegetation depends on quality and size of seed, number and character of the species in the mixture, etc. Generally, with most range species, about one viable seed per square inch is necessary for establishment of an adequate stand. Some of the quick starting and vigorous species can be sown at a slightly lower rate, and, conversely, some of the species which have very small weak seedlings that are slow to establish require a higher rate.

An old gardener's rule says that "seeds should be sown at a depth three times their own thickness." This, although not literally correct, implies that small seeds must be sown at a very shallow depth, while larger ones can be planted deeper.

When seed is sown in mixture, as is usually the case, we regulate the depth of seeding for the smallest seeds in it. Good results have followed seeding on the surface and squeezing the seed into the ground with a corrugated roller. Many of the revegetation failures have been due to seed being covered too deeply. Too deep planting has resulted from a seedbed that is too loose, from broadcasting on the surface and disking too deeply, and from seeding in the bottoms of furrows in which silt subsequently collected.

We have adapted machinery to the seeding conditions found in the Southwest region after considering these important factors: economy of operation; prepa-

ration of seedbed; seeding depth; firming of soil about the seed; ability to use the various kinds of seed in mixtures without stoppage and maintaining an even mixture whether the hopper is full or nearly empty. Modified seed drills are doing this very satisfactorily where they can be used.

Seeding in furrows is done by broadcasting with a modified dust blower. All the disturbed strip is seeded. Covering is effectively done by means of a light brush drag drawn by the operator of the duster. On freshly broken furrows, broadcasting the seed without the use of any covering equipment has been very satisfactory, as natural openings, clods, slacking of the soil, etc., cover the seed adequately.

We have obtained some good results from seedings on steep hillsides, arroyos, dams, banks, dykes and other locations where machinery could not be used, by broadcasting, then handraking and brush dragging and trampling by sheep. However, such practices are not as successful as drilling, and we use them only where drilling is not possible.

Great areas of sagebrush land present one of our greatest revegetation problems. These areas once were grassland-sagebrush savannahs, but overgrazing has practically destroyed the grass and the sagebrush has increased until it constitutes nearly all the cover. Erosion is very severe and carrying capacity is low.

The lessening of sagebrush competition is desirable in many areas before grass can be established. Experience to date indicates that in large areas, dragging down the sage is the most practical method. Seed broadcast before dragging is covered by the dragging operation. The sagebrush debris protects the ground surface against wind and water erosion, and the young seedlings against wind, sun, and too close grazing.

In the early days, many of the grass species adaptable to our region had not been tried, and revegetation had not been attempted to any extent under such conditions as are encountered in the Southwest. But during the past few years every conceivable method has been tried under our varied conditions. Although many of our efforts to date have not been too successful, they have supplied us with a fund of information which we feel justifies us in recommending extensive seeding operations in what we consider our more favorable sites, with proved species, by proved methods.

CRESTED WHEATGRASS

(Continued from p. 60)

are killed by hot winds occurring before the plant becomes well rooted. Late spring and summer seedings usually are unsuccessful for this reason and because of early damage from grasshoppers. The optimum date of seeding is from August 20 to September 20, provided there is ample moisture in the soil and grasshoppers are not prevalent. The next best seeding date is in the late fall, from about October 20 until the soil freezes in the late fall or early winter. Early spring seeding, before April 20, has proved the third best period.

The proper depth of seeding is a factor that cannot be too strongly emphasized. Many stands have failed because the seeding was too deep. As crested wheatgrass seed is rather small (there are some 200,000 seeds per pound) the amount of stored food in the endosperm is very limited and does not serve to push the seedling through a deep cover of soil. The recommended depth of covering is about one-half inch, and for this reason it is especially important that supervision be given the cooperating farmer in getting the drill adjusted and calibrated so as to assure proper coverage of the seed.

The grass seed mixture used in seeding idle lands is usually wasted unless the seeding is performed on a firm or hard seedbed that is free from all looseness and airpockets. The soil will "firm up" naturally if it is undisturbed, or if a small grain or Sudan grass crop is produced on the soil the first year and grass is seeded in the stubble after the crop has been harvested.

Where the land to be seeded has a vegetative cover, no additional seedbed preparation is needed. If the soil is barren and drifting, the grass seeding operations must be postponed until after a vegetative cover has been produced and the soil stabilized. This necessary vegetative cover can best be obtained by drilling the field to small grain, preferably rye or Sudan. Grass-seeding operations will then be carried out in the fall, following the emergency cover crop.

After it has been seeded special care should be given each field, until it becomes well established. This care consists primarily of withholding grazing during the first year and until the grass has started growth in the spring of the second year. Experimental grass plot work in Nebraska indicates that undisturbed grass produces, in a single growing season, twelve times as many roots as similar grass plots continuously clipped during the first year's growth. The top growth is very dependent upon the root developments.

The plan is that when idle or abandoned lands have been seeded to a perennial grass mixture and have

(Continued on p. 67)

This field of fall wheat stubble, averaging 3 tons or over per acre has been disked three times to a depth of 7 inches.

CROP AND TILLAGE ROTATIONS COMBINE FORCES IN THE PACIFIC NORTHWEST

THE environmental contrasts within Region 9 (Washington, Oregon, and Idaho) comprise a testing ground for seed, seed mixtures and residue utilization as applied to a wide range of conditions. Continued observation of practices is providing a basis for refinements of technique, and for determination of land-use capabilities as a general guide for site identification. The latter need has been met by "minimum requirement charts" prepared for each principal work area and based on land-use capabilities as determined by soil type, slope, and degree of erosion.

This approach to the development of a technique or formula to be followed in determining a safe, long-time cropping system has been found very helpful in developing a common understanding among the technical staff, as well as an appreciation of the problems on the part of cooperating agencies.

During the past 4 years on the Palouse project (Moscow, Idaho), sweetclover and grass rotational seedings that have been plowed under and cropped to wheat have produced an average increase of 12 bushels per acre over untreated land. Within the various portions of the intermountain wheat belt, where rainfall corresponds with that of the Palouse section, this practice has resulted in increased yields and improved soil condition.

Since the development of grass-legume rotational seedings to the point of maintaining a relatively constant acreage, an increase of approximately 20 percent in the number of cattle within the Moscow project has been reported. A definite trend is also noticed toward increased fall usage of this type of pasturage by range cattle from surrounding areas. Quick-growing semipermanent grasses are now being used with sweetclover for rotational seedings, and long-lived grasses have been included with alfalfa in permanent pasture and hay seedings. The proportion of grass to legume has been adjusted to meet soil and climatic conditions. Development and use of new grass accessions, made available by the soil-conservation nurseries, has been of outstanding importance.

Field trials are being conducted in cooperation with a few operators who will produce a limited number of outstanding accessions under the State seed-certifi-

cation program. Quotas have been established for "uncommon" seed—seed ordinarily not available through commercial channels. The operations program will require about 80,000 pounds in the fall of 1939 and spring of 1940, and 105,000 pounds during the fall of 1940 and the spring of 1941.

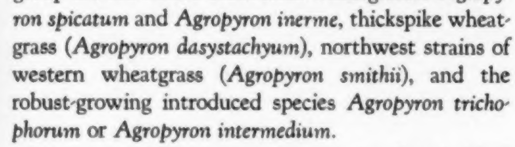
Although the more common commercial grass species, such as crested wheatgrass (*Agropyron cristatum*), slender wheatgrass (*Agropyron pauciflorum*), and smooth brome (*Bromus inermis*) have been extensively used in the past in rotational seedings with sweetclover, these grasses are not ideally suited to the purpose because of their slow-growing habits. It is thought that development of larger seeded, more vigorous growing species will pave the way toward increased use of grass with sweetclover. Among the more promising species being considered as substitutes are mountain brome (*Bromus marginatus*), blue wild-rye (*Elymus glaucus*), Canada wild-rye (*Elymus canadensis*), big bluegrass (*Poa ampla*), and perhaps bulbous barley (*Hordeum bulbosum*).

For permanent retirement, or for use in long rotations, a number of native and introduced species give promise of wider use to replace the common commercial species formerly included in seeding mixtures. In this group are the native bluebunch wheatgrasses *Agropyron spicatum* and *Agropyron inerme*, thickspike wheatgrass (*Agropyron dasystachyum*), northwest strains of western wheatgrass (*Agropyron smithii*), and the robust-growing introduced species *Agropyron trichophorum* or *Agropyron intermedium*.

In the vernal dominant group are Sandberg's bluegrass (*Poa secunda*), or the robust form, Canby bluegrass (*Poa canbyi*). Bulbous bluegrass (*Poa bulbosa*) is rapidly extending its range of use and is considered an important component in range reseeding mixtures.

Of the bromegrasses, improved strains of smooth brome (*Bromus inermis*) are coming to the front, and mountain brome (*Bromus marginatus*) because of its ease of establishment and wide adaptation is valuable. Erect bromegrass (*Bromus erectus*) is finding a place on severely eroded sites under areas of low to moderate rainfall.

Of the ryegrasses, blue wild-rye (*Elymus glaucus*) and Canada wild-rye (*Elymus canadensis*) are the most promising because of their high seed yield, wide adaptation and ease of handling. In the fescue group,



Idaho fescue (*Festuca idahoensis*) is an important component in the native vegetation; it has poor seed habits, however, and will require additional selection and breeding. At present, strains of sheep fescue (*Festuca ovina*) are promising. Robust and uniform strains of red fescue (*Festuca rubra*) are being increased and they may find general use where other fine-leaved fescues are adaptable.

Among the primary invaders for use in initial seeding of denuded areas, particularly those with light and sandy soils, are the ricegrasses, the dropseeds, the needlegrasses and the squirreltails. The most promising species are, in the order named, Indian ricegrass (*Oryzopsis hymenoides*), and the sand dropseeds *Sporobolus cryptandrus* and *Sporobolus airoides*. A species of needlegrass which is of particular interest in soil conservation is *Stipa viridula* because of its broad leaves, robust growth, recovery after cutting, and growth at low temperatures. Red three-awn grass (*Aristida longiseta*) is very abundant, particularly in overgrazed areas but, although it possesses some forage value in early growth, its seed characteristics discourage wide use. Of the squirreltails, *Sitanion jubatum* and *Sitanion hystrix* are common invaders of overgrazed areas. They are drought-resistant and they set seed abundantly and shatter readily. In the early growth stage they are readily eaten by livestock.

The advantageous use of rotational seedings and adapted species in vegetative protection of soil is effectively supported by tillage methods that enable utilization of crop residues. Field trials prove that the greatest value of crop residues lies in their maintenance as surface mulch during the critical erosion period. Farmers in areas subject to severe wind erosion have made the greatest progress in utilization of crop residues. Their efforts and those of men of the Service have shown that initial tillage operations can be adjusted so that the major portion of these residues can be left on the surface without interference with subsequent operations and with no adverse effects on production.

Because of climatic conditions, a typical problem is encountered in the utilization of residues in the wheat-growing sections of the Northwest. The zones of relatively high rainfall usually produce abundant straw, whereas in the lower rainfall areas, subject to wind erosion, residues usually are light. Protection of the soil during critical erosion periods requires a flexible tillage system to secure maximum benefits from proper use of residues. In every instance a surface cover of such residues is of primary importance. It is

(*Continued on p. 72*)

ORCHARD COVER CROPS IN THE PACIFIC SOUTHWEST REGION

By CHARLES B. AHLSON [1]

THE USE of annual or winter cover crops has been a standard practice for many years in irrigated citrus, avocado, and deciduous orchards in the Pacific southwest region. From the standpoint of securing maximum erosion control in hillside orchards, this practice is far from perfect, inasmuch as the soil is not protected from early rains in the fall of the year or from late rains after the cover is turned under in the spring.

Information gathered in a survey by the Service [2] of permanent or continuous cover on 23 irrigated orchards in California indicated that the practice was considered by these growers to be preferable to an annually planted cover. Permanent cover, combined with little or no cultivation, gave practically complete erosion control in these orchards. Cultivation costs were also reduced and the quantity and quality of the fruit produced averaged equal to or better than that of orchards where other cultural practices were followed.

A knowledge of climatic factors is necessary for appreciation of the erosion hazards encountered in California orchards. The bulk of the rainfall is in the late fall and winter months, and high intensities are frequently recorded. Usually the temperature is mild enough during the rainy season to permit the germination and growth of cover-crop seed. The critical period for cover crops is the fall of the year. It is difficult to establish adequate cover, early enough in the fall to check erosion, by depending on precipitation, and for this reason many growers irrigate so that a good cover can be established at the proper time.

Where a permanent or continuous cover is used, the soil receives maximum protection from erosion. Growers who follow the practice generally mow the cover and use it for mulching around the trees, or simply leave it where it is cut. A few of the growers who were interviewed do not mow the cover or disturb it in any way.

The type of plants used for continuous cover varies. Some growers perfer native annuals consisting of early maturing grasses and legumes, such as bromes, fescues, wild barley, and bur-clover. As a majority of these species germinte with the fall rains, enough seed generally matures to provide new growth in the fall. The old growth and litter give the soil some protection from washing while the new growth is coming up, and rank-growing weeds which mature seed later than the native annuals are gradually eliminated by mowing.

Some growers prefer a cover of perennial grasses and legumes, including Italian ryegrass, bluegrass, orchard grass, Ladino clover, white Dutch clover, and red clover. Alfalfa is also used, but in general it is not as desirable as the other species mentioned. In deciduous orchards, the growth is often pastured instead of mowed, if the grower has facilities for a combined fruit and livestock enterprise.

Those growers who were consulted by representatives of the Service stated that no specific or radical changes in pest control or fertilization were necessitated by a permanent cover.

For proponents of the practice of clean cultivation, attention is called to the reduction in orchard cultivation that has made steady progress in the last 10 years. In an article entitled "Putting Farm Efficiency Records to Practical Use" that appeared in the Extension Service Review for June 1939, by Harold E. Wahlberg, farm advisor, Orange County, it was stated that "over a period of years, the study shows that the more profitable orchards actually receive less cultivation than the less profitable orchards. In 1938, the 20 more profitable orchards of the 60 in the study reported an average cultivation cost of $9.67 per acre whereas the 20 least profitable orchards reported $16.13 per acre . . . A large majority of our orange growers have reduced their hours and costs of cultivation during the past 10 years about 50 percent, some even more."

Permanent cover can be readily established with a sprinkler system of irrigation. Where furrows are used for irrigation, the broad shallow type [3] is preferable to the V-shaped furrow, as it provides a more uniform seedbed. The erosion that usually occurs in the V-shaped furrow is largely eliminated.

The use of annual or winter cover in deciduous nonirrigated orchards is increasing. In the Corralitos demonstration area in Santa Cruz County, clean cultivation was the general practice until the last few years,

[1] Chief, regional agronomy division, Pacific Southwest Region, Soil Conservation Service, Berkeley, Calif.

[2] Permanent Cover in Irrigated Orchards, by Charles B. Ahlson and George Hutchinson. SOIL CONSERVATION, February 1939.

[3] Advantages of Broad Furrow Irrigation, by Colin A. Taylor, Pacific Rural Press, March 18, 1939, pp. 262-263.

although the county farm advisor had recommended the use of annual cover in hillside orchards. The inception of soil conservation demonstrations, and increasing appreciation of the erosion hazard on the part of the growers—gained by tours held by County Farm Advisor Henry L. Washburn in cooperation with the Service—has established the use of winter cover crops in combination with trashy cultivation. In the deciduous irrigated orchards of the Placerville demonstration area, approximately three-fourths of the orchards are now in permanent cover.

Avocado trees, uniform and vigorous in tree growth, density and height of cover. The orchard has not been mowed or cultivated since 1927. The man is pointing to the header irrigation furrow from which the water is diverted to individual tree basins.

Although there are a number of problems relating to the use of permanent cover, including that of water requirement, that have not as yet been solved, the value of the practice for erosion control is beyond question. At the present the Service is conducting evaluation studies on demonstration areas for clarification of some of these problems.

In a few instances, winter cover cropping has been combined with basin listing in deciduous orchards. On gently sloping land and permeable soils this practice is of value both as a soil and water conservation measure. In those orchards where the slope is steep and the soil relatively impermeable, it has not been successful.

The increased use of perennial or annual cover with a minimum of cultivation, or no cultivation, in irrigated orchards is striking evidence that growers are aware of the necessity of curbing erosion and of reducing the cost of cultural operations. The study that was made of 23 irrigated orchards where permanent cover is used included the principal orchard areas in California where erosion is a problem. The results indicated that this practice might be used to good advantage more generally in those areas as well as others. At least, further observations, studies, and tests should be made.

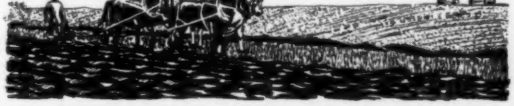
The growers usually gave five reasons why they use a permanent or continuous cover in their orchards: (1) It eliminates cost of annual seeding, (2) reduces cost of cultivation, (3) allows little or no soil loss, (4) allows less run-off, and (5) quality and quantity of production are equivalent to or higher than without cover.

CRESTED WHEATGRASS

(Continued from p. 63)

become established the grass will remain permanently on the field. However, for northern Great Plains areas of light-textured soil and higher rainfall, to be used for continuous cropping, the Service is recommending a long-time grass legume rotation: Part of the farm is to be seeded to grass to remain for several years, and then it is plowed and another part of the farm is seeded. By this arrangement, all the cultivated land will be in grass once in 20 years.

Crested wheatgrass plays an important part in this program, since Canadian experimental results indicate that it has a total root fiber content of 5,079 pounds per acre in the upper 6 inches of the soil. This enormous quantity of root fiber, when periodically returned to the soil in a long-time grass rotation, not only binds the soil, improves the soil structure, aids in balancing the carbon nitrogen ratio, increases the absorptive capacity of the soil, and minimizes erosion, but also assists in stabilizing farming operations and establishing a permanent system of agriculture.



HOW TO USE OUR GREATER ACREAGE OF HAY

By A. T. SEMPLE [1]

UTILIZING the hay crop is a subject of considerable concern to Soil Conservation Service field men who are helping farmers to replan their farms and ranches for soil and water conservation. Certain land-use capabilities call for certain crop rotations which involve the production of corn or other feed grains, and hay or other roughage, in a rather definite relationship. This results in a problem of utilizing these crops to the best advantage in feeding various kinds and market classes of livestock. Naturally, it is difficult to make much use of large amounts of hay or silage in fattening hogs or feeding poultry. On the other hand, a herd of beef breeding cows may be kept almost wholly on roughages, while fattening yearlings require a longer feeding period and a greater proportion of concentrates than do 2-year-old steers.

Of course, there may be some argument as to whether we should fit the livestock to the crops we should grow on the soils that we have, or try to adapt the soil to the production of crops necessary for the kind of livestock we want to keep. I believe we will be safer and come nearer effecting a permanent agriculture if we start our planning with the soil that we have and the physical conditions surrounding it, grow the crops, grass, trees and shrubs which are best adapted to the soil with adequate consideration for its protection, maintenance, and improvement, and keep the kinds of livestock which can make the safest and most economical use of the feed crops. As a matter of fact, most farmers do adapt the number and type of livestock to the crops which the farm produces to the best immediate advantage. In the exceptional cases, farmers purchase the feeds which the nature or extent of their land does not permit them to produce, but which are needed by the livestock they are keeping. This is especially true of operators who purchase carload lots of feeder cattle and sheep to be fattened for slaughter, and who keep dairy cows for fresh milk production on high-priced land near large cities.

Dependence by some farmers on purchased feeds, such as grain and hay, means that other farmers are following what is commonly called the grain system of farming and may be keeping only enough livestock to supply home needs for meat, milk, and farm power. Unfortunately, many grain farmers do not keep enough livestock to meet home requirements and must use the cash proceeds from their crops to purchase what they could have produced readily on their farms. Such uses of cash for goods which should have been produced at home naturally limits the improvement of farm living standards because it reduces the amount of cash available for the purchase of goods which farmers are not able to produce on their farms.

A friend of mine in the field of animal husbandry stated recently that there had been too much experimentation in the feeding of crops which should not have been grown. He meant by this that far more concentrated feeds such as corn, oats, cereal byproducts and cottonseed meal, have been produced than can be marketed profitably, and more than a fair share of research work and funds have been expended on the problems of utilizing such concentrated feeds in the fattening of livestock. This explains to a large extent the inadequacy of information on the use of hay, other roughages, and pasturage in growing and fattening livestock.

Paul Gerlaugh and C. W. Gay [2] of the Ohio Agricultural Experiment Station have conducted an excellent series of experiments, covering 3 years, which show the effects of reducing the corn and increasing the hay in the rations of fattening yearling steers with hogs following them to pick waste corn. Each lot of steers received 1.5 pounds of protein supplement and practically 14 pounds of silage per head daily, as shown in the following table.

*The rations and daily gains of yearling steers fattened on heavy, medium, and light feeds of corn and the acreage of feed crops required for such methods of feeding.**

	Lot 1 Full feed of corn	Lot 2 Three-fourths full feed	Lot 3 One-half full feed
Average daily feed per steer:			
Corn and cob meal . . . pounds . .	13.3	10.1	6.7
Protein supplement . . . do	1.5	1.5	1.5
Silage . . . do	13.7	14.1	14.2
Legume hay . . . do	3.2	6.2	8.7
Average daily gain in weight . . . do	1.91	1.78	1.69
Average acreage of feed crops per lot of 12 steers acres . .	15.24	14.76	13.86
Average gains of the cattle per acre of feed crops pounds**.	387	369	368

* The steers averaged 691 pounds per head and were fed for an average of 240 days. Each lot contained 12 steers for each of 3 consecutive feeding periods, beginning in the fall of 1935.

** The gains of hogs following the cattle to pick up waste feed are included in each lot. The gains of the hogs per acre were 26, 20, and 14 pounds for lots 1, 2, and 3. respectively.

[1] Head, pasture section, agronomy division, Soil Conservation Service, Washington, D. C.

[2] The Bimonthly Bulletin, May–June, 1939. Ohio Agricultural Experiment Station, Wooster, Ohio.

Loading hay on a contour strip in eastern Iowa. If the soil is to be adequately protected from erosion, if its productivity is to be maintained or improved, and if people and property in river bottoms are to be protected from floods, crop rotations must provide for having cropland in perennial grass and other erosion-resisting and soil-building vegetation a considerable part of the time.

Decreasing the corn and cobmeal from 13.3 pounds daily to 10.1 pounds daily and increasing the legume hay from 3.2 to 6.2 pounds per head daily cut the daily gain from 1.91 to 1.78 pounds, but did not affect the selling price per 100 pounds of the live cattle or adversely affect the color of the carcasses. On the heavier grain feed, the cattle and hogs gained 387 pounds per acre of land producing the feeds. On the lighter grain ration the cattle and the hogs gained 369 pounds per acre.

The average of 3 years' work with a third lot of yearling steers, fed 6.7 pounds of corn and cobmeal and 8.7 pounds of legume hay in addition to the protein supplement and silage, averaged 1.69 pounds gain per day. The average gain per acre of land used in producing feed was 368 pounds. These steers, getting a light feed of grain and correspondingly heavy feed of hay, sold for about 6 percent less per hundredweight. There was no appreciably adverse condition in the color of their fat.

Feeding the cattle the heavy grain ration required 5½ acres of corn for each acre of hay. The medium grain feeding required 2.3 acres of corn to 1 acre of hay, while the cattle receiving a light feed of grain consumed 1.2 acres of corn for each acre of hay consumed. These figures take into account the corn used for silage as well as grain in each case.

The relatively good showing in gains per acre, of the cattle getting the light grain ration, indicates the possibilities of keeping a large proportion of the farm in perennial meadow, using the hay to feed steers and getting them fat enough to meet the demands of the beef trade. It should be kept in mind that in fattening beef calves a higher proportion of grain to hay is necessary than in fattening yearlings. An excellent 4-year rotation of crops for soil-building purposes in the Corn Belt consists of 1 year of corn, followed by small grain, and 2 years of clover and perennial grass. All of the grain, hay, straw, stover silage, and pasturage produced by such a rotation of crops may be used economically by beef cattle. Obviously, all farmers are not interested in producing beef cattle exclusively, but there are many other possibilities for using to advantage a relatively large acreage of hay in feeding livestock. I think we should mark up another score for grassland farming.

All of this is an excellent sequel to and fits in very nicely with the comparison of livestock and grain systems of farming which was started by the Ohio Agricultural Experiment Station at Wooster in 1910.[3] In each system, a crop rotation of corn, soybeans, wheat, and red clover was used for the first 20 years. Then sweetclover was substituted for red clover. In the livestock rotation, all the manure produced in feeding the crops, excepting the wheat, was returned to the land with practically no waste. In the grain system, no hay was made and all the crop residues were left on, or returned to, the land. The land in both systems has had the same soil amendments including limestone, 320 pounds of 20-percent superphosphate applied each

[3] Progress of Agricultural Research in Ohio, 1936–37. Bulletin 592. Ohio Agricultural Experiment Station, pp. 24–26.

A beef breeding herd on winter range in eastern Wyoming. Such ranges produce more cattle and sheep than can be fattened on the feeds raised in the West. Livestock therefore is shipped to the Corn Belt and the East, where more feed is produced than the local livestock can use. Adequate protection of the soil will help to maintain this important relationship.

time the land is in corn, and 240 pounds of 20-percent superphosphate preceding each wheat crop. In addition, in the livestock system, manure has been spread on the land each fourth year, when it is in corn, at the rate of 2.28 tons per acre.

A comparison of crop yields per acre, in livestock and grain farming, at the Ohio Agricultural Experiment Station at Wooster, 1910–36

	First 10-year period	Second 10-year period	20-year average	7-year average 1930–36
Ear corn:				
Livestock farming..........bushels..	67.3	86.3	76.8	70.0
Grain farming...............do....	59.2	79.8	69.5	* 69.2
Difference................do....	8.1	6.5	7.3	.8
Soybeans:				
Livestock farming............do....	21.7	25.1	23.4	27.7
Grain farming..............do....	19.1	22.0	20.5	26.8
Difference.............. ..do....	2.6	3.1	2.9	.9
Wheat:				
Livestock farming...........do....	32.5	33.8	33.1	36.1
Grain farming..............do....	29.4	29.7	29.6	29.3
Difference...............do....	3.1	4.1	3.5	6.8
Clover hay: Livestock farming.....tons..	2.24	2.68	2.46	2.08

* There were two very poor corn crops in the last 7 years.

These data show striking differences in favor of livestock farming and indicate that livestock farming is a more effective method of maintaining and improving soil fertility than grain farming, provided all the manure is carefully saved and applied to the land. While in each system of farming equal quantities of lime and phosphates were being applied, the land in the livestock system actually received greater accretions of fertilizing materials than that in the grain system. The grain land lost all the fertilizing elements in the grain, including the corn, wheat, and soybeans which were harvested, while the livestock land lost about a fifth of the fertilizing elements in the corn and soybeans and other roughages, principally hay, which were consumed by livestock. The losses in the case of the wheat were the same in either case, and there were no appreciable losses in the roughage used for bedding.

Livestock on the average farm excrete about 80 percent of the nitrogen and other fertilizing elements contained in the feed they eat.[4] Cows and other female stock when they are pregnant or giving milk, and young growing stock, excrete a smaller percentage of the nitrogen phosphorus and potassium contained in their feed, while mature and fattening stock excrete a larger percentage of these elements. Naturally, the building of bone and muscle and the secretion of milk make it necessary for the animals to remove from their feed more of the fertilizing elements in the form of various proteins and minerals than is necessary for fattening, maintenance, farm work, or other draft purposes. Very young calves and lambs may store two-thirds of the nitrogen and minerals in their feed. Two-year-old steers being fattened may excrete as much as 87 percent of the nitrogen and phosphorus they consume.[5]

Failure to take satisfactory care of manure is a common weakness in livestock farming as it is generally practiced. Unless manure is properly handled, it will lose fully one-half of its value for crop production before it reaches the land. Proper handling consists of such practices as adding 30 pounds of superphosphate per ton of manure to guard against losses of nitrogen in the form of ammonia, using enough litter to absorb the liquids, tramping to prevent fermentation and loss of ammonia, keeping under cover by means of water-tight flooring, and spreading evenly on

(*Continued on p. 72*)

[4] F. B. Morrison: Feeds and Feeding. Twentieth edition (1937), p. 413.

[5] Grindley, Mumford, Emmett, and Bull: Illinois Agricultural Experiment Station Bulletin 209.

BOOK REVIEWS AND ABSTRACTS

by Phoebe O'Neall Faris

THE ROLE OF PLANT LIFE IN THE HISTORY OF DUTCHESS COUNTY. By Edith Adelaide Roberts and Helen Wilkinson Reynolds. Vassar College. 1938.

Carefully compiled ecological studies supported by historical findings are welcome to a Service whose chief interest is reclamation and protection of the soil—the Soil Conservation Service. The first author is on the staff of the Department of Botany at Vassar, and the second is a member of the Dutchess County Historical Society. The two have worked well together to produce a monograph that identifies all the vegetation of their county and to show clearly the historical use of the land and its results in relation to the future.

The reviewer has been informed by the authors that their monograph will be used for supplementary study in erosion-control education at Vassar. It is reviewed here because it should prove valuable in a conservation education program anywhere. Its pattern is closely defined from an ecological standpoint, and the many interesting and intimate stories of Indian occupation and sawmill and gristmill days, and of trees and shrubs, herbs and grasses fighting for life from bog to upland, all emphasize the urgent importance of an understanding of environmental conditions for plant life as protection for the soil.

The study opens with an excellent description of the development of plant life under present conditions on the uplands and in the lowlands of Dutchess County lying on the east bank of the Hudson, in the middle part of the valley, between Red Hook and Fishkill. The numerous observation notations—of an old oak here, an herb there, an aquatic on the edge of a young stream—show that the authors tramped many a mile over their county to establish environmental factors before compiling their data into an account of the succession of associations. The climax plant formation of the area is the beech-maple-hemlock association; and the story as told here, of plant associations—open field, lake and pond, bog, river and stream, ravine—as they climb toward this goal (or would climb, given the opportunity) is much more comprehensible and informative, to the beginning as well as the trained ecologist, than is a volume on general ecology.

The geologic past of the area, with the vegetation of the periods, is sketched briefly. Some inaccuracy is found here, possibly editorial or typographical, but an accompanying geological map (after Robert Black) gives an idea of the age of the area formations and is interesting when used in conjunction with the remarkable aerial map from the cover pockets. This map, in two very large sheets of excellent quality paper, is indeed an innovation in vegetation studies.

Soil, land moisture, precipitation, light, and temperature are treated from the standpoint of plant growth and adaptation. Here is the indication that water retention of the soil has lessened with the cutting down of the forests during the past two or three hundred years.

The device of Indian place-names is employed rather effectively to show how the Red Man used the vegetation of Dutchess County. From the known facts concerning the tribes who occupied the area, the authors infer " . . . that the Indians appreciated fertile soil, that they had an occasional clearing or field where they raised corn, beans, squash, and tobacco, that they cultivated fruit trees, and that in general, they cleared only the timber along the stream sides." A map of Indian encampments goes with this part of the monograph.

The section which tells of the white man's relationship to plant life in this once completely forested area is a thorough piece of work and is also important historically. Mills—sawmills that the trees from advanced associations might become "fine Dutch barns" or handsome panelling for chimney-breasts and cupboards, or clapboards and shingles, and gristmills to grind the grain raised on the land shorn, a little at a time, of its forest—mills had a great deal to do with exploitation by the white man. As it happened, between the 1680's when the first mill was built by Madame Brett in the Rombout Patent, and 1867 when mills numbered 113, the original vegetation had disappeared except for a lonely old beech here, a group of silver maples there, an ancient tulip tree guarding a ruined stone foundation. (A sketch map of the county in its modern form, showing the old trees, is included.) By 1880, 95 percent of the land area of Dutchess County had been converted by the white man into farms—and then came the recession.

The soil, robbed of its protection, could not endure. By 1930, but 65 percent of the land was in farms; the 45 percent dropped from cultivation is today slowly working its way climax-ward. The Juniper and Gray Birch Associations are seen on some of the uplands, and the Shrub Association of scrub oak appears where land many times burnt-over is now protected. As to the swamp areas, the authors suggest that they should perhaps be allowed to return to the Oak Association: "In the more advanced swamps plantings of red oak, white oak, and hickory could be made and the lowland succession speeded up and made more use of . . . The mosquitoes would be reduced by such planting and the water level would be maintained . . . A permanent water supply may be conserved in this way and the land is not needed for cultivation. This applies to the entire county."

Plant life in the future development of Dutchess County, New York State, is emphasized in a final secton of the monograph. And, briefly, we are told of the plan to establish the Dutchess County Outdoor Ecological Laboratory, under the Department of Botany of Vassar College, ". . . to make possible the fullest utilization of the plant life . . . through a complete knowledge of the individual plants of each of the associations." It is to be a "plant use" laboratory, its chief objective the supplying of information concerning production and aesthetic and economic uses of all the plant members of the area's associations. Some sample planting lists are included along with an interesting sketch of home-site arrangement.

Finally, the study presents an alphabetical list, by botanical nomenclature according to Gray, of herbs, trees, ferns, and shrubs belonging to the various plant associations of the county. There are 1,055 plants listed, and common names are given for the amateur—and for the delight of the philologist with special bent toward the romance of words!

An 88-item bibliography includes works on ecology, botany, Indian geographical names, soils, doorways and period work in woods, daily light periods for plant growth, and many other subjects into which the authors of this monograph delved for a thorough understanding of the future needs of the land of their county as well as its primeval conditions and its early history.

A WORLD TOUR FOR THE STUDY OF SOIL EROSION CONTROL METHODS. By A. Grasovsky. Institute Paper No. 14, Imperial Forestry Institute, Oxford, England. 1938.

A year or so ago the chief forester of Palestine, Dr. A. Grasovsky, came to this country to study soil conservation and reforestation practices as carried out in the Middle and Western States—those areas with problems similar to his own in the ancient country bordering the eastern Mediterranean. Naturally his chief interest was cover for desiccated land, for the control of erosion and to build up forest soil. As he had already visited the Sahara and had studied anti-desiccation work in Nigeria, reforestation methods in Algeria, and sand dune fixation in Morocco he was well equipped to judge with an appraising mind what he observed of soil conservation work in Colorado, New Mexico, and Arizona, Utah and Texas, and in forest experimental stations farther east. From this country he went to the Far East and returned to Palestine via Japan, Java,

BOOK REVIEWS AND ABSTRACTS

continued

Malaya, Ceylon, and India. His report, called "A World Tour for the Study of Soil Erosion Control Methods," is most illuminating; it displays a cosmopolitan basis for understanding and for presenting the findings in a way that adds much to their value for the author's American associates. The discussion of American methods is trenchant and substantial, in places frankly critical, but at the same time gives due weight to erosion-control activities as "bound to be of benefit to the country generally, and . . . of great importance as a new departure."

It is especially interesting to learn just what practices and experiments in what areas of the United States appeal strongly to the chief forester of Palestine. The work of our Service in Navajo land he calls "a most interesting soil conservation undertaking" and points out pasturage improving, water spreading, fruit tree planting, ravine-bed stabilizing, and livestock exchange—better breeds and fewer animals—in the 16 million acres of desert-border land as showing "how much can be done with semiarid areas if they are properly and intelligently managed." In the Middle West, Dr. Grasovsky's attention was arrested by windbreak and woodlot planting of the Service on farms requiring protection from wind erosion. Of the Rio Grande project where he found much to interest him, he sums up his observations thus: "The chief significance of the work lies in the fact that all operations in the territory are organized by one department which, having studied all the details, and taken into consideration all the various interests involved, develops comprehensive schemes, each covering a whole water-catchment area. The purpose of this unification of control goes far beyond the mere management of a few demonstration plots: the ultimate aim is to secure properly planned utilization of the whole vast and complex area."

Dr. Grasovsky points out that in his opinion much of the erosion-control experimental work is still concerned with demonstrating on specific areas facts which have long been scientifically established, with the object of arousing the interest and sympathy of the American public in erosion control. "Nevertheless," he adds, "all who are interested in erosion and desiccation problems should be gratified that, at long last, these problems are now occupying the minds of the American people, who are perhaps preeminently in a position to devote the necessary time and money to their solution, and to the eventual discovery of ideal methods of control."

In his chapters on African desert regions, Dr. Grasovsky gives an interesting description of the middle Sahara. He tells of water courses lost in sand, of oases, meager vegetation and animal life, the great central plateau, lofty mountains and no evidence of flowing rivers. In the near-Nigeria area, which had been denuded by over-use, complete recovery was seen, and there were also local indications that vegetation is invading the desert rather than that desiccation is spreading outward. In Algeria, revegetation was the only method of erosion control being used: Allepo pine, cedars, cypress, cork oak were planted on badly denuded slopes; black locust in ravines; eucalyptus on river banks and newly formed alluvial flats.

While in the United States, Dr. Grasovsky visited the Appalachian Forest Experiment Station, the Lake States Stations at La Crosse and Huron, the California Forest and Range Station on the Sierra Madre Mountain range, and the Desert Range Experiment Station at Milford, Utah. He presents significant findings at these stations with considerable detail. It is apparent throughout his discussions that his chief concern while on world tour was to discover soil and water conservation methods that would be adaptable to arid Palestine. His report is receiving considerable attention among thoughtful conservationists in this country.

ACREAGE OF HAY

(Continued from p. 70)

the fields in as fresh a condition as practicable. Letting the manure accumulate in open lots, and under the eaves of barns without spouts, is the worst kind of treatment, as rainwater may leach out fully half of the plant food contained in the fresh manure. If open lots must be used, the smaller the better, provided the stock have room to stand in the sun in the winter and in the shade in the summer.

The mere fact that a farmer is feeding all of his crops to livestock or that he is buying feed from his neighbors does not prove that he is maintaining the productivity of his fields and pastures. As a result of failing to save the organic matter and soluble nutrients in the manure, the livestock farmer may actually be depleting his farm more rapidly and allowing erosion to proceed more rapidly than his neighbor who is practicing grain farming and seeing that all crop residues are returned to the soil and used as cover and as a source of organic matter. In either system, with no significant losses of soil by erosion, soil amendments such as limestone phosphates and potash are necessary to replace the minerals which are removed from the farm by the sale of grain, livestock, and milk.

CROP AND TILLAGE ROTATION

(Continued from p. 65)

especially important where vegetative protection provides insufficient control of erosion.

In wind erosion areas utilization of crop residues begins at harvest. The straw scatterer distributes cut straw uniformly over the stubble where it may be handled to provide a surface mulch if later tillage is modified for this purpose. Subsequent tillage with the lister bottom, the modified moldboard plow or the one-way disk has been successful in obtaining this result. When the one-way disk is used, one disking is considered sufficient.

Fallow operations with the rod weeder are favored because of the effectiveness of the implement in weed suppression, and because in operation it disturbs only a shallow layer of soil, thus preserving a maximum amount of soil moisture. The rod weeder also assists in preserving a trashy surface. If the disk drill is used, seedbed preparation for fall wheat may not require an additional tillage step.

In heavy stubble, frequently encountered where annual rainfall is more than 16 inches, fall disking is required as a means of assisting in decomposition and reduction of stubble.

U. S. GOVERNMENT PRINTING OFFICE: 1939